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ABSTRACT

Presented is a unit designed for curriculum infusion and which relies on the hands-on discovery method as an instructive device. The student is introduced to the theory of a functioning salt water conductivity meter. The student explores the resistance of salt water as salinity increases and he treats the data which he has gathered, mathematically, using Ohm's Law as a vehicle. The unit may be easily infused into a high school chemistry, physics or advanced biology course. (Author/EB)

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Investigations in Marine Chemistry:

Salinity I

by

Richard M. Schlenker

SE 021 289

Abstract

The unit is designed for curriculum infusion and relies on the hands-on discovery method as an instructive device. The student is introduced to the theory of a functioning salt water conductivity meter. The student explores the resistanse of salt water as salinity increases and he treats the data which he has gathered, mathematically, using Ohm's Law as a vehicle. The unit may be easily infused into a high school chemistry, physics or advanced biology course.

Preface

There are many aspects of chemistry and electricity which are assumed to be in the instructors repertoire of background knowledge. However, there are a few facts and cautions concerning this unit which should be mentioned.

Pure water will not readily conduct an electric current; however, extremely sensitive meters will detect a current flow even in the purest water. To minimize this effect, distilled water should be used.

In order that the investigations achieve the greatest degree of success, the salt water solution should be a homogeneous mixture. To insure that this condition exists, the students should be instructed to mix the salt and the water as throughly as possible.

When the probe is inserted in the salt water and the switch closed, a current flows. When this condition exists, the copper plates react with the solution. While these reactions are beyond the scope of this unit, the reactions do cause buildups on the plates. These buildups effectively increase the resistance between the plates and thus decrease the amount of current flow which can occur between the plates. The buildups increase as the length of time the probe is immersed increases, they are not instantaneous. For this reason the probe should be inserted briefly and the current reading taken as soon

as possible after immersion. After a reading has been taken, it is a good idea to rinse the probe in fresh or distilled water. It is also a good idea to periodically clean the probes with steel wool.

As the depth of probe immersion increases, the amount of surface area presented to the water increases. As the area increases, the area available for electron release to and retrieval from the solution increases. It follows that as the depth of penetration increases, the current readings will increase. In order to obtain uniform and meaningful results, the depth of penetration should be held constant as one makes a series of measurements. The readings, for example, included in the following pages of this unit, were taken at an immersion depth of 7cm.

It is hoped that this list of cautions, while not intended to be exhaustive, will produce a more meaningful unit for the student.

Investigations in Marine Chemistry:

Salinity I

Introduction

Most of the organisms living in the inshore areas of the world's oceans are euryhaline. The degree to which salinity changes in these areas during each tidal cycle, as well as the degree of tolerance each species has to salinity changes, partially determines its' ability to live at a given location. The student's understanding of these concepts is basic to his true understanding of intertidal and tide pool ecology. One method by which students could begin an investigation of the salinity parameter is the subject of this unit. The unit is essentially one of discovery and makes extensive use of the hands-on technique.

Salinity can be measured by a variety of methods. One method is to use the saline water's conductivity. This is a method often used by commercial manufacturers of salinity and conductivity meters. The method is made possible because of the salt water's ability to conduct current flow. As it turns out, the magnitude of the current flow is directly proportional to the salinity of the water. This unit will lead the student to discover that saline water conducts current.

Objectives

1. To introduce the student to salinity.
2. To introduce the student to conductivity as a method of measuring salinity.
3. To introduce the student to electrical and mathematical relationships which are useful in measuring salinity.
4. To introduce the student to components necessary to build an inexpensive salinity meter.
5. To introduce the student to an electrical diagram of a salinity or conductivity meter.

Goals

Upon completion of this unit, the student will;

1. Be able to build a conductivity meter.
2. Be able to discuss saline water's conductivity in terms of Ohm's Law.
3. Be able to draw an electrical diagram of a salinity meter.
4. Be able to graph the relationship between salinity and conductivity.

Materials

1. Several 500ml beakers. Other containers may be used as long as the size is constant from container to container.
2. One 6 volt battery.

3. A quantity of fresh water.
4. One milliammeter, 0-1 amp.
5. Two copper plates, approximately 1cm x 10cm.
6. One piece of wood, 1cm x 1cm x 10cm.
7. A length of string.
8. One on/off toggle switch (optional).
9. Four lengths of number 12, 14 or 16 wire with alligator clips on each end.
10. A quantity of table salt.
11. A pan or other type of balance. Other types of measuring equipment will work.
12. One graduated cylinder per pair of students.
13. One 6v bulb and socket.
14. Four 250ml beakers per pair of students. Alternative the same as that for 500ml beakers.

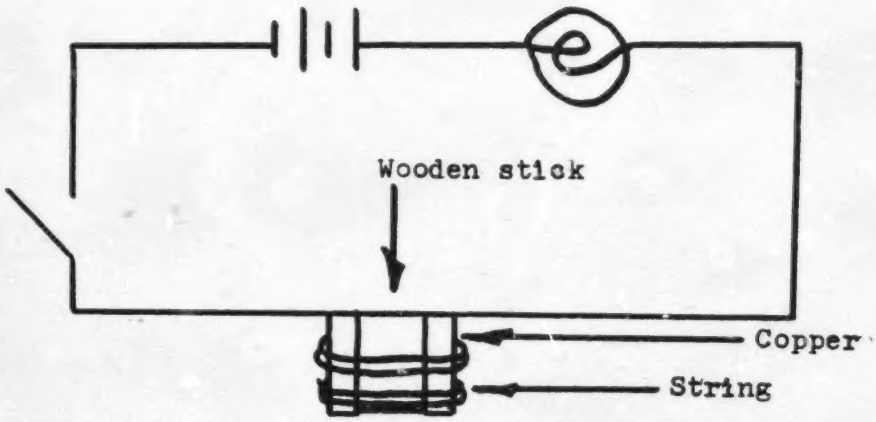
Procedures

1. Introduce the students to the following electrical circuit symbols;

Length of wire | Meter | Lamp | Switch | Battery

2. Each student group should fill several beakers with 400ml of fresh water (fill at least four).
3. Weigh and dissolve the following amounts of salt in three beakers, 5g, 2½g, 1 1/4g.

4. Build the following circuit.



5. Insert the electrode probe in each of the beakers and close the switch. The student should find that;

   A. The light remains extinguished while the probe is immersed in pure water.

   B. The brilliance of the bulb increases as the concentration of salt increases.

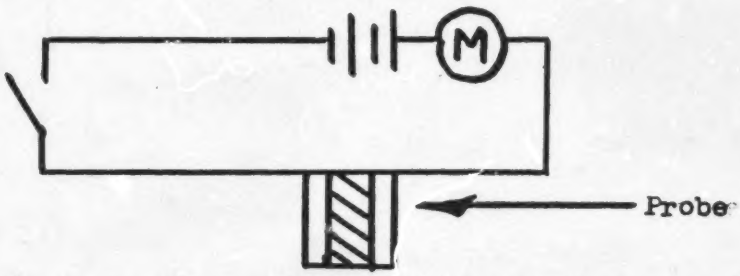
At this point, the student should begin to question what takes place when salt is added to the water. If this does not happen, the instructor should insert a few leading questions.

$$NaCl \longrightarrow Na^{+} + Cl^{-}$$

Water is a poor conductor of electricity; however, when NaCl is added (and dissolved), the solution readily conducts electricity. As is evident from the equation given above, every sodium chloride molecule which dissolves in water one positively charged sodium ion and one negatively charged chlorine ion. It follows that the

electrical current must be passing through the water with the aid of the negatively and positively charged ions. When some force (electromotive force or voltage) is applied, Cl^- ions will move in one direction, while Na^+ ions will move in the other direction. The Na^+ ions move in the direction of the negative plate of the probe and since each ion is positive or has a deficiency of one electron, each Na^+ ion has the ability to accept one electron at the negative plate. Each Cl^- ion has the ability to accept one positive charge at the positive plate of the probe. Viewing the Cl^- ion another way, since each ion has one extra electron, it has the ability to deliver that electron to the positive plate. In any event, the final result is current flow through the water.

6. The light bulb should now be replaced by a meter. The new circuit should appear as follows;



7. The probe is now inserted in each beaker. The student should begin with the beaker filled with fresh water and work in the direction of increasing salt content.

8. The current readings obtained in step #7 should be recorded. Using a 6V battery and a 0-1A meter, graduated in milliamps, the following approximate results should be obtained;

   pure H_2O---------5ma

   1 1/4g NaCl-----220ma

   2 1/2g NaCl-----380ma

   5g NaCl---------880ma

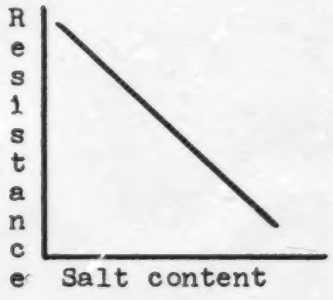
9. Introduce the students to Ohm's Law, E = IR, where E = voltage, I = current and R = resistance. It should be remembered that when voltage is in volts and current in amps, resistance is computed in ohms. A simple method of remembering the Ohm's Law relationships is;

10. Ask the student to hypothesize a relationship between salt content or salinity of the water and current flow, salinity and resistance.

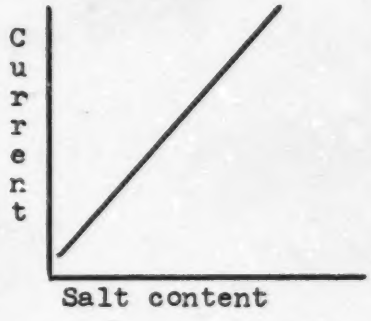
11. Using the values of current flow obtained in step #9 (they should be in amps, 1000ma = 1A), substitute for I in the Ohm's Law formula. Since the value of voltage is constant at 6V, this value can be substituted in each calculation.

12. Graph the data gathered in step #11, comparing (1) salt content of the water and resistance, (2) salt content of the water and current flow. In each case, x and y coordinates should be used. In the graphing it should be remembered that salt content is the independent variable, which by convention lies on the x axis.

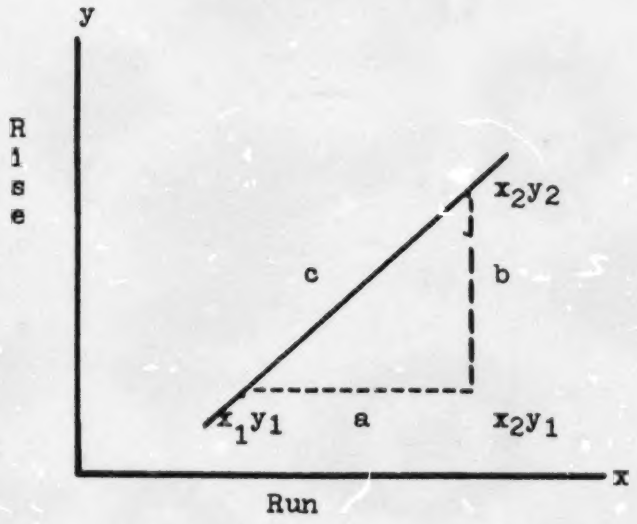
Graph 1



Graph 2



The formula for the plotted line is $y = mx + b$, where m = slope or rise/run, b = y intercept, x = the distance along the x coordinate and y = the distance along the y coordinate. The slope may be interpreted in the following way, (1) for every unit which salt content increases, resistance decreases a certain amount, rise/run = resistance/salt content, and since resistance is decreasing as salt content increases, the slope is negative, m = -resistance/salt content, (2) the same logic holds in this case except that the slope is positive, m = current flow/salt content. The mathematical value of the slope can be found via the following method;



$(x_2 - x_1)$ = length of the run

$(y_2 - y_1)$ = length of the rise

m = rise/run = $(x_2 - x_1)/(y_2 - y_1)$

From this discussion, we see that in order to successfully make one of these plots, at least two values of resistance and salt content are required. The same logic holds for the current flow and salt content relationship.

current flow (y)	y_1	y_2	y_3
salt content (x)	x_1	x_2	x_3

Using a chart such as this allows for easy substitution of the necessary numerical values.

13. Using the values obtained in the measurements of the beakers, compute the mathematical of the slope for each condition.

Evaluation

1. Obtain the necessary parts and physically construct a simple conductivity meter.

   A. Draw an electrical diagram of the meter you have constructed.

2. Using four 250ml beakers, fill each with 200ml of fresh water. In three of these beakers, dissolve the following amounts of NaCl, 1/2g, 1g, 1 1/2g.

   A. Measure the conductivity and graph your results.

3. Discuss the results of step #2 in terms of Ohm's Law, slope, salt content, conductivity etc,

Vocabulary

1. Conductivity----A measure of the ability to conduct something.
2. Current flow----The movement of a charge from one point to another.
3. Electromotive force----The force exerted by a battery or other generating source which causes current to flow in a closed loop or circuit. Commonly called voltage.
4. Euryhaline----A characteristic which allows organisms to withstand fluctuations in salinity.
5. Intertidal----The physical area between extreme high and extreme low tides.
6. Ion---- An atom which carries a negative or a positive charge.
7. Ionic solution----A solution which allows conduction of an electrical charge.
8. Negative charge---- A condition of a body which indicates that it possesses an excess of electrons.

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9. Ohm's Law----Current flow is directly porportional to the amount of voltage present and inversely porportional to the amount of resistance.

10. Positive charge----A condition of a body which indicates that it possesses a deficiency of electrons.

11. Resistance----A quality of a body which limits or controls the amount of current it is able to pass.

12. Salinity----A measure of salt content. In the world's oceans, it is normally measured in parts per thousand, and abbreviated o/oo.

13. Slope----A mathematical relationship, rise/run.

14. Tidal pool----A pool of sea water which is left as the tide recedes.

15. Voltage----See electromotive force.